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Vertebrate Ecology of Arno, Marshall Is.  
by Joe T. Marshall, Jr.

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SIM has developed as a successor to the former CIMA project with an enlarged scope that includes field research in the physical, biological, and life sciences. Field work under SIM has been conducted in Guam, American Samoa, and in the islands of the Trust Territory in Micronesia since 1949 with transportation and facilities contributed by the Department of the Navy. The field research has been carried out in co-operation with universities, museums, research institutions, and Government agencies under this project of the Pacific Science Board of the National Research Council, supported by the Office of Naval Research and aided by financial assistance from the Viking Fund and other private sources.

VERTEBRATE ECOLOGY OF ARNO ATOLL,  
MARSHALL ISLANDS

SCIENTIFIC INVESTIGATIONS IN MICRONESIA

Pacific Science Board  
National Research Council

Joe T. Marshall, Jr.  
University of Arizona  
Tucson, Arizona  
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### Objectives

It was my desire to record observations in the field on individual animals in their natural state. This information is preserved in my field notebook covering the period from early June to early September, during which time I was in residence at Arno. As few of the birds were nesting, and consequently very few were tied down to any restricted area, it was difficult to keep track of individuals. Most of the birds ranged over very large areas, but I did get continuous records on some for most or a large part of the summer: a certain Golden Plover (identified by his ragged primary feathers), a pair of reef herons, a nesting pair of pigeons, and a recognizeable flock of each of the following: crested tern, black-naped tern and turnstone. In addition, two brown Emoia lizards, which returned to certain roosts at night, and a school of porpoise were repeatedly observed in their appropriate places. For most of the species, however, I have considerable observations which disclose some interesting facts on distribution, aggregation into flocks, feeding methods, time of activity and movements, even though it was impossible to follow individuals.

Since the vertebrates (other than some of the lizards) found here are widely ranging over large areas in the Pacific and are well known, it was not thought necessary to do much collecting of specimens, aside from picking up an individual or two to look for parasites and stomach contents. I actually preserved 140 vertebrate specimens, most of them lizards.

My field observations make up the bulk of this report. The results of my collections of parasites and vertebrate specimens must wait (at least for some of the specific identifications) for determination by various experts on special groups.

### Disposition of Specimens

Immediately upon landing in the U.S., I distributed specimens for identification as shown below. This is not necessarily a final disposition, and if you know of any institution that has a logical claim on any particular specimens, I would appreciate knowing it.

Concerning the lizards, I have corresponded with Dr. Myers of Stanford, the only person I know who might be working on Pacific reptiles in general, and he stated that he was not contemplating any particular project on Marshall Island reptiles; therefore, I have decided to work the lizards up myself, and publish the results separately. This study for one thing will involve trying to find names for the things, as you can tell from the strange vernaculars I have invented for them in the accounts which follow. I was amazed to learn from Dr. Myers' assistant that several of my Arno lizards were different from those which Myers obtained on Bikini! For this study it will be of help if I may borrow the specimens I donated to Dr. Wells of Cornell, and perhaps Dr. LaRivers will be so kind as to loan me the specimens he collected on Arno, provided he is not contemplating a major opus on them.

All mammal skins and skulls (2 species of rat, porpoise) and the only important bird skins (2 topotypes of a race of the Micronesian Pigeon found only in the Ratak Chain) to the U. S. National Museum.

Additional bird skins and skeletons: University of Arizona, Dept. of Zoology, Tucson.

Reptiles: Now at University of Arizona being worked up by myself; part of the collection is being sent to Cornell University and will be examined and identified.

Land snails taken from the intestine of the "Mennuel" lizard to Yoshio Kondo, Bishop Museum, Honolulu. This is the only item for which I have already received an identification. Mr. Kondo very promptly and kindly wrote (23 October):

"The shell fragments you found in the skink's intestine are undoubtedly from several specimens of Omphalotropis fragilis Pease examples of which we recently acquired from Likiep, a nearby atoll. This is an operculate snail that lives under stones and debris throughout most of the Caroline Islands and it recently came as a surprise from the Marshalls and, I may add, as a jolt, out of a reptile. Snails are eaten by rats, birds, other snails, and perhaps by our mongoose but this latest is surely a new one on me."

I hasten to add that the lizards which have thrown the scientific world thus into such transports, were collected by Drs. Stone and LaRivers. Intestinal protozoa and helminths of man, chicken, pig and native birds to Dr. Harold Kirby, Jr., Department of Zoology, University of California, Berkeley.

Intestinal protozoa of termites together with specimens of the termite hosts to Dr. Harold Kirby, Jr. When my flight out of San Francisco was delayed, I despaired of having enough time in Honolulu to gather equipment for preserving parasites. Dr. Kirby came to my rescue with his "complete termite kit" which made it possible for me to preserve slides and specimens of parasites of man and other animals as well as of termites. He is furthering our project by having his assistants stain and identify our human protozoa slides, etc., and it is only fitting that he should be given his beloved termite material - in fact that was his stipulation in lending me the kit.

Intestinal flagellates of lizards to Brontislaw M. Honigberg, Department



of Zoology, University of Massachusetts. A student of Dr. Kirby, Honigberg is writing his doctoral thesis on the flagellate faunules of reptiles' rectums.

Ectoparasites of wild birds and mammals (at the suggestion of Dr. Usinger) to Communicable Disease Center, U. S. Public Health Service, 605 Volunteer Bldg., Atlanta, Georgia.

#### Accounts of Species

Marine Turtle, Won.- Seen only three times, in the lagoon.

1/ Rock Gecko, Kirabro.- This nocturnal lizard lacks the frilled adhesive discs found on the toes of the other geckos, consequently it is our only gecko that stays on the ground. It lives among rocks, and individuals are found on successive nights at their respective boulders. They are agile and can leap, but usually prowl slowly among the rock crevices. By day they may be found under stumps and logs or under piles of coconut husks. Two taken at 10 a.m. under a pile of husks had fresh food in their mouths, showing that they feed in the daytime in their dark retreats. Stomachs disclosed: their own skin, large centipedes, weevil, large spider, sand fleas, beach crickets, other small insects, some plant material. (In this and following stomach analyses, the insects have been identified by Dr. LaRivers.) Parasites: usually a couple of dozen nematodes attached in lining of stomach, rectal flagellates abundant. 6 specimens.

2/ Small House Gecko, Korab.- This small species is found abundantly in houses, and less commonly in Pandanus and Pipturus trees where it forages by climbing along slender twigs and hopping from leaf to leaf. In houses

1/ Rock Gecko (Gymnodactylus pelagicus).

2/ Small House Gecko (Lepidodactylus lugubris).

they begin hunting in late afternoon, and can climb vertical window panes. They are nocturnal, but are active for a longer period than the other geckos, being seen in late afternoon and early morning. By day they hide in the dead leaves of Pandanus, crevices in houses, under piles of coconuts, and under fronds and pieces of drift-wood on the beach. They do some feeding in these places during the day; two out of five collected at 11 a.m. under fronds and sticks on the beach, had fresh food. They can change color, and are usually dark in the daytime and very pale at night, but can change to agree with the substrate. Their call is a sharp "click, click" like two small pebbles striking together; a mating display was witnessed, involving jerky progression and sinuous waving of the tail. Food consists of small insects: ants, termites, Drosophila, sand fleas, and winged ants. A singular lack of habitat restriction is evidenced by the finding of individuals roosting by day in such places as houses, beach below the high tide mark, crown of a coconut tree, etc. The only parasites found were the rectal flagellates; 8 specimens were preserved.

1/ Big Tree Gecko, Korab Kiro.- This is the largest and most abundant gecko found on Arno; it is active during the hours of darkness. It is easily detected at night by its large red eyeshine (reflected from a flashlight) and one or two can be seen on just about every coconut palm, crawling along the midribs in search of insect food. They also climb along the slender palm leaflets, which their weight causes to bend down, and they cannot be shaken off by hand or by a strong wind, for the frilled pads on their toes virtually glue them in place. The tiny hairs on these pads

1/ Big Tree Gecko (Gehyra oceanica).

are apparently not easily wetted, for contrary to Loveridge's expectations (Reptiles of the Pacific World) I found these and the Small House Geckos in numbers climbing up wet surfaces immediately following a violent downpour of rain. These geckos are also found in thatched houses, Pandanus trees, but can most regularly be seen on tall dead coconut trunks, where there are crevices under the bark for hiding. They appear to avoid dense groves of breadfruit trees, and I saw only one individual in the King's breadfruit grove all summer. Of the hundreds of individuals seen, not one was on or near the ground. One afternoon I found four adults hiding in a "skirt" of hanging dead leaves surrounding a Pandanus stem. I found none by day in my "hectare" transect area; they probably roost high in the coconut crowns. Call notes and mating were observed in a house roof on July 7. The call is a loud, petulant "kraaaaaaaa." Mr. Strasburg found a community nest: 14 eggs were in a hollow under some rocks at the base of a coconut stump. Any one female has only two ripe eggs at any one time. Stomach contents revealed their own skin, crickets, ants, crane flies, other insects. Fifteen specimens of all ages were preserved. These yielded in addition to the usual rectal flagellates, some interesting parasites: a stomach nematode, and rather large tapeworms in the small intestine.

1/ Four-fingered Gecko, Korab.- This rare species closely resembles the Big Tree Gecko, but has a tail like that of the Small House Gecko, and the first digit is reduced in size. I saw only two on trees at night, and a third was brought to me by the village boys. Two specimens, rectal flagellates present, food of moths.

1/ Four-fingered Gecko (Hemiphyllodactylus typus).

Mennuel or "terrible lizard".- This giant skink was appropriately discovered by Dr. Stone some time after he had learned of it through Kontu, who translated the Arnoese name of a certain plant as "sleeping place of the terrible lizard." Stone found two, and Dr. LaRivers one at Arno Island, on the ground, in the daytime. This gentle but formidable appearing animal is greatly dreaded by the Arnoese, but is certainly harmless. The three male specimens had no parasites; remains of land snails, Omphalotropis fragilis were found in their intestines.

Dasia smaragdina, Kiliij (green form), Aueb (black form).- This strictly arboreal skink is the diurnal counterpart of the Big Tree Gecko, and one or two can be seen on almost every coconut trunk during their hours of activity from about 7:30 a.m. to 5 p.m. (if sunny). They may remain motionless for long periods, pressed against the clear trunk, with the head held out at an angle. On uninhabited islands where there is denser vegetation, they will come lower in the leafy understory of vines and shrubs, but are rarely found on the ground. They occur on just about all the islets of the atoll; though I found none on Autore, one was seen on tiny Rakijer, much smaller than Autore, and containing only 3 or 4 coconut palms. A little islet next to Rakijer, which had only a growth of Scaevola, lacked any lizards of any kind. Dasia sleeps at night on the trunk, wherever they happen to be at the end of the day, as evidenced by the fact that individuals will seldom be roosting at the same spot on successive nights.

Their usual coloration is bright green, but some individuals are olive, yellow-green, brownish, black, or dark with yellow edgings to the scales, a very beautiful pattern. At Ine, I could expect to see only



two blacks out of fifty, but on islands at the east end of the atoll, such as Tagelib, Kirage, Ijoen, Rakaaru, etc., one usually saw a black one in every four or five.

Dr. Stone brought in an average sized Geograpsus crinipes (land crab) from the mouth of its hole at the base of a breadfruit tree, which he had caught in the act of dismembering and devouring an adult Dasia of fairly large size. Seventeen stomachs showed a diet of various insects: beetles, winged and non-winged ants, maggots, sow bugs, cockroaches, moths, etc.; two had plant material, one of them probably the white fruit of Scaevola. Eighteen specimens were saved, the rectal flagellates were in abundance, and the tiny nematodes often found in stomachs were probably escapees from the insect food.

Emoia cyanura, Kiruble (or Kirible).-- This little blue-tailed skink is the most numerous land vertebrate on the atoll. It was abundant on all islands visited except one tiny islet of Scaevola only a few yards wide. It is found on or near the ground on piles of coconuts, fallen fronds, vines, gravel areas near the beach, lower matted dead leaves of Pandanus and thatched houses. There will be five or six on every pile of coconut husks, and they are so numerous in sunny vine areas, that there is a constant rustling as they jump from leaf to leaf; about one every square yard here! They rarely go up trees other than Pandanus, and I have seen them fall off when they attempt to scale smooth overhanging trunks. They are remarkably agile, and have a jerky, fast progression. They eat insects and some fruit (Scaevola), and in turn are eaten by herons, chickens, and possibly by the land crab, Ciserna. I once watched this crab pursue a

skink along a Pandanus leaf, and the skink hid by pressing itself into the groove running along the middle of the leaf, such that it was almost impossible to see. They are active from 7:30 to five, preferring the sunlight. They are not found roosting in the open as are the other skinks, for they seek hiding places under rocks at night. 29 specimens were kept; as usual, flagellates were found abundantly inhabiting their large intestine and cloaca.

Ground Emoia, Karable (brown form), Aoeb (black form).-- For the present, I am considering these two forms as being races or variants of the same species, because never were both to be found on the same island, and furthermore, the few young individuals that I was able to find of the black Emoia had some brown coloration suggestive of the pattern of the brown form. It will be noted from the Arnoese vernaculars that the Arno people do not make a distinction between the black phase of Dasia, which is always found in trees, and the black Emoia, found almost exclusively on the ground. (On the other hand, these people recognise that all three radically different color phases of the Reef Heron belong to the same species.) Young individuals of the brown Emoia are colored like the adults.

The distribution of the two forms is shown on the accompanying map. (Figure 1)  
The species is absent on small islets such as Nameji and "Island No. 7"; Autore is the smallest island on which I found this skink. It is met with on the ground, rocks, piles of coconuts, base of breadfruit trees, gravel beaches under Scaevola trees, and in houses, but it avoids dense vines and shrubbery. Those found on the bases of breadfruit trees commonly

run up and around the buttresses of these trees a few feet above the ground, but only once did I see one on a coconut trunk. This was an individual which I collected on Ijoen; it was affecting the manner of Dasia by clinging to the trunk 10 feet above ground, and holding its head out perpendicular to the axis of its body. It could be distinguished from the black Dasias in similar poses nearby by its shorter head, held out at a more rakish angle. This species is less abundant than E. cyanura (appropriate to its size): a coconut pile or base of a breadfruit which harbors half a dozen of the latter, will have only two of the former. One or two can be found at the base of almost every breadfruit, when there is a clear space there uncluttered by vines.

These skinks forage by deliberate movements, showing a strong tendency to crawl and poke their heads under things, such as under rocks, under mats on the floor. They crawl through the thatched roof to sun themselves on the top. They are tame and may climb over a person during their pursuit of insects. Food consists of earthworms, ants, maggots, other insects, and occasionally rotten breadfruit. One was eaten by a New Zealand Cuckoo which I collected. It is strange for a ground inhabiting lizard that likes to go under things that it should seek a higher perch in the open for roosting at night. I kept two such roosts under observation for about a month and found that one individual which roosted on a coconut leaflet four feet above ground was there three out of six nights, and another on a Pipturus leaf at the same height, was there eight nights out of eleven. They would occupy these roosts from about 6:15 p.m. until 7 a.m., and during the darkness would be fast asleep with eyes shut. They begin their activity in the morning when the sun shines on the

bases of the breadfruits, at about 7 to 7:30 a.m. 27 specimens were preserved, showing in the way of parasites, in addition to the prevalent rectal flagellates, stomach nematodes and a nematode encysted in the mesentery.

The strange mutually exclusive distribution of the two forms of this Emoia is the most startling fact brought out by my modest researches on Arno. In continental areas two races of the same species will usually have each its own continuous area of distribution, and where the two areas adjoin, intermediate specimens will be found. But here, the two forms are interspersed in what seems like a haphazard manner, and continuity is evidenced only within the population of any one islet, where the individuals are all very nearly the same. The closest I found the two to each other was between Autore and the south end of Chittakinmatoroen, a distance of about a third of a mile. The black Emoia was on Chittak, and the population of Autore was brown. It would be of immense interest from the standpoint of evolutionary studies, to interbreed the two in captivity and determine the genetic picture of their differences. Also it would be of interest, if anyone could spend a longer period of time in study at Arno, to release both forms on an island which has neither (such as Nameji), and see if one would survive at the expense of the other. It is very easy to catch these skinks with a simple noose, and a whole batch of them could easily be caught and brought together with most edifying results by one fortunate enough to spend considerable time on the project. If one assumes that both forms have equal opportunity to be transported (say in Pandanus roof thatching which the faithful bring from all parts of the atoll for adorning the church at Ine) from island to island, then why do we find only one or the other (not both, not a mixture) surviving on any island?



Demigretta sacra, Reef Heron, Kabaj.- This heron is a permanent resident found on reefs throughout the atoll in numbers of about four to the mile. I found no direct evidence of nesting during the summer, although a specimen taken July 17, had a greatly enlarged oviduct and two ruptured ovarian follicles, and Dr. Wells observed copulation in a pair that I had under observation all summer at Ine Anchorage. I never witnessed this act nor did I find a nest, though I saw these two engage several times in rather elaborate mating display, and one would generally chase away any third party that might arrive. These chases may take the birds clear out of sight out over the ocean. Particular birds prefer a certain reef for foraging and may be there several days in a row, but others may come in and three or more birds may feed in the same spot during the course of a day.

These herons experience difficulty in getting food at high tide, and may spend a lot of time getting little or nothing from the sand-clouded waves at this time. If there is a high tide at dawn, they sit around and wait for the water to drop, after some futile efforts at foraging, or they may try their hand at catching skinks up in the vegetation. I have watched them thus catching Emoia cyanura at Ine. Apparently they can get plenty of fish in a short time if the tide is low, because they will sit around motionless for long periods on the reef or perched on horizontal coconut fronds even when the tide is low - after their feeding. A stomach contained the following fish, such as are commonly found in lagoon tide-pools (these and all subsequent fish identifications are by Mr. Don Strasburg): 1 Gobius ornatus, 1 Goby sp., 2 Salavicus lineatus, 1 Lutianus sp., 1 Acanthurus triostegus and a shrimp (Palaemonidae). A peculiar bathing habit was witnessed in which the bird squats for several minutes

in a pool, with just the head and shoulders sticking out. A single specimen was preserved; it had louse flies but no endoparasites.

Gallus gallus, Fowl, Kako (rooster), Lala (hen).-- The fowl is found abundantly around human habitations. They were kept in pens only by the preacher at Ine, who had about 20 in a screened enclosure. These were terribly infested with parasites as a result of the ease with which their droppings could contaminate the food. Some fairly independent families of chickens are located several hundred yards away from the edge of town, and there was a large flock abandoned on Ijoen, where there is only a seasonal population of people (harvesting coconuts). There were no truly wild chickens such as are found far from humans in the woods and jungles of Palau, for instance. Chickens are eaten here only on special occasions, and the Arnoese don't like eggs. As a result, there appears to be a great excess of chickens over what are actually needed for food. They function in cleaning up wastes and scraps throughout the villages. I never saw them molested by cats or dogs. They eat seeds, ants, maggots, beetles (the entire insect fauna such as is found on the ground and in rotting fallen breadfruits), grass, leaf hoppers, skinks, and coconut meat. For the most part they forage on their own, but some people feed them coconut meat in the evening, along with all their other domestic animals. Parasites are abundantly found in these fowl: nematodes such as Ascaridia, Capillaria, Acuaria, tapeworms, and Protozoa such as Trichomonas and Entamoeba. Nevertheless the chickens which are not kept in pens appear to be hardy and robust, as well as prolific. There is plenty for them to eat, even without the help of humans, as evidenced by the healthy flock, including many young chicks, which followed at my heels all over deserted Ijoen.

Pluvialis dominica, Golden Plover, Kolej. (In the black breeding plumage it is called Kolej lakek).-- The following applies to all five shore-birds found here: These shore-birds breed in the far north, and young and old alike spend the winter in such places as Arno. The following summer the adults go back to their breeding grounds but the immature birds remain on through their second summer and second winter, and do not even acquire the breeding plumage during this "over-summering" period. Thus all the plovers seen at Arno were immatures in residence for the entire period of the study, except for one seen on June 15, which was in breeding dress. However, by September 2, an influx of birds from the north was underway, as evidenced by many which were beginning a molt from the breeding plumage to the winter dress (new white feathers coming in on the black under-parts). A bird with ragged primaries occupied the stretch of sandy lagoon beach by our headquarters all summer, and was seen daily. About half a dozen of these birds are found per mile, along beaches, reefs, and inland in grassy or cleared areas or trails through the forest. They forage off and on all day, beginning very early (about 6 a.m. when barely light), becoming very active at dusk. They are heard in flight and are active on moonlit nights. They forage in the manner of a robin, on marine dipteran larvae (Tendipedidae), small nereids, small crabs, bits of seaweed, Halobates blown up on the sand; earthworms, etc. from inland. Plovers occur singly or in groups of 3 or 4 and may associate loosely with tattlers and turnstones to the extent that these three species may join in flight, but each pursues its own manner of independent feeding when they alight. Plovers are the most numerous of the five shorebirds, and are the least restricted in habitat. One specimen was taken; it was infested with mites, but the small flukes and larval tapeworms in its

digestive tract were probably from their food items.

Numenius tahitiensis, Bristle-thighed Curlew, Kowak.- I saw only eleven of these birds; they were restricted to areas of broad gravelly tidal exposures as found on the north and east horns of the atoll. They were probably around all summer but not detected until I visited such areas July 29 - August 25. The curlew feeds on crabs - it grasps one in the tip of the long beak, raises it high in the air (over the bird's back) and whacks it down on the rocks, picks it up again, and repeats the performance until the crab is dismembered and can be swallowed.

Limosa lapponica, Godwit.- Only one was seen, at Pikaareji on August 25, probing energetically with its long straight bill into the soft sand of an exposed tidal flat. It was probably seeking various invertebrates as food. It could have been an over-summering bird or a newly arrived migrant from the north.

Heteroscelus incanus, Tattler, Kidir.- The tattler is found on rocky reefs throughout the atoll and is usually solitary, but sometimes two may be seen together. Not until August 25 was a flock seen (6), possibly consisting of newly arrived migrants. Although no breeding would take place at Arno, a mating flight was seen on August 3: two flew high in small circles over Ine Village, a couple of feet apart, uttering continuous calls. They forage on rocks at the edge of the water, and only rarely at very high tides will they get along the sandy beach. One was watched thus pursuing the very swift Ghost Crabs (Ocypode ceratophthalmus). With the aid of its wings, the bird was able to run as fast as the crabs, and would follow them into the wavelets, but it was impossible to see if it actually



caught any of them. It probably did, for it kept at this type of foraging, strange for this species, for a half hour, and could not be seen at close range nor collected, because people kept coming out on the beach to perform their morning functions, thus scaring the bird farther and farther away. Since for the most part they are strictly confined to rocky exposures, they come into contact with turnstones more than with other shore-birds, and though they may fly with these turnstones, they forage independently. They begin their activity at the crack of dawn (about 6 a.m.), and are commonly heard in flight over reefs on moonlit nights. These birds are widely spaced, but constant in occurrence - one on almost every separate patch of reef, or at least a couple per mile.

Arenaria interpres, Turnstone, Kōtkōt.- It was difficult to determine the length of beach patrolled by individual shore birds, but at least they were often seen making long flights from one exposed reef to another. With the Kōtkōt, however, a flock of four was around Ine Village all summer, and it roamed over at least a mile and a half of beach. By August 29 and September 2 an influx of new birds from the north was indicated by flocks of 11 and 14 respectively, around Ine. The habitat of the Turnstone is rocky coral shores, but it prefers smooth coral pavement or flat pebbly areas where it can run along and "tip up" to catch its invertebrate food. Dr. Hiatt identified invertebrates found in stomachs of this and following species. A stomach of a Turnstone contained small crabs: Dacryopilumnus rathbunae and xanthid crabs such as found in rocky upper tidal reaches. At the time that a Tattler was chasing ghost crabs on the beach, the Turnstones were attracted to the scene and attempted to copy the Tattler in chasing these swift crabs. With their short legs,

however, they were unable to get anywhere with these crabs, and finally gave up and sat around watching the energetic Tattler.

The Turnstone is definitely gregarious - solitary birds are only temporarily away from the flock. They are caught alive and used as fighters by the Arnoese. A group is found every mile or so of reef. Parasites of the single specimen taken were mites, slender nematodes from the stomach wall, large flukes and tapeworms from the intestine, and flagellates in the caecum.

Sterna sumatrana, Black-naped Tern, Keer brik.- This small tern is found abundantly where there are sand spits or gravel exposures (for resting) near large expanses of shallow water (for feeding). As many as fifty were seen together. Adults, immatures and juveniles could be recognized by their distinctive plumages, but there were no newly-hatched juves to be seen, indicating that nesting had taken place prior to our study. A flock of nine was around Ine Village all summer; in a good noddy fishing flock, these would be joined by others coming in low and straight from great distances, attracted by the milling noddies. The nine used to make a circuit of the anchorage each morning at about 6:50. They forage by diving from about 25 feet above the water, but sometimes swoop low trying to catch small flying fish in the air. They do not poise before the dive (as do the Crested Terns), but plunge right in with no wasted motion or time. They gather at favorite reefs as they are exposed by the tide and spend a lot of time sitting there on the rocks at the water's edge, often joined by Crested Terns. Two specimens were taken; their stomachs contained the clupeid Stolephorus delicatulus, the herring-like fish sought by Sterna and the noddies when driven to the surface by tunas. There

were no parasites except bird-lice and mites.

Thalasseus bergii, Crested Tern, Keer mot.- These giant terns feed on mullet, the clupeid Harengula ovalis, and sometimes chase flying fish. They hunt by diving from a height of 25 to 75 feet as follows: a bird over a favorite shallow water fishing site swings into the wind, poises and rises, suddenly faces down and rolls about a half turn as it plummets down to sink half under the water, rises into the wind, swallows, shakes out its feathers (clearing them of water), flies straight on, then circles back to the starting point. One group got only one fish out of 11 dives, another morning they took 6 fish out of 9 dives. Prodigious distances are covered in foraging, and single birds can be seen in the middle of the lagoon, bound from one end of the atoll to the other. They are widely distributed in the lagoon, but do not go far out over the ocean. They do not join the noddy fishing flocks, but feed on their own or in company with Black-naped Terns. They are active from dawn to dusk, but spend much time sitting together on rocks. Two adults and 3 immatures were usually around Ine Village; sometimes others joined them to augment the flock to 9 or 11. One specimen was taken, which, for parasites, had only mallophaga and mites.

Anous stolidus, "Large Noddy", Rabbit.- These birds were seen on the ocean between Arno and Majuro and in various parts of Arno Atoll: a few at Arno Island, Pikaareji and Autore, many along the western part of Ine Island, and huge concentrations from Nameji to the eastern extremity of the atoll, where they vastly predominated over the Small Noddy. Big fishing flocks were observed in the latter area, where they differ from Small Noddy flocks by their continual whining cries. The night (no moon)

was made hideous by their growling and shrieking at Rakaaru, where they flew around the trees all night. The next morning they were all sitting around roosting in palms, in two large concentrations. One at Autore acted menacingly, as if it were protecting a nest, but I found no actual evidence of nesting at this season. One specimen was taken; it had no internal parasites, but in its plumage were mites, mallophaga and louse flies. The food consists largely of bait fish scared up by tuna.

Anous tenuirostris, Little Noddy, Jökar.- The various roosts where these birds congregate between feedings seem to have in common that they are on the smaller islands near extensive shallow water areas, and are in trees, from which the birds can keep track of the fishing flocks out in the lagoon or ocean, and join them at appropriate times. Large roosts were at Island No. 7, Tagelib (two, with old nests in breadfruit trees), Autore in Ochrosia and Scaevola, Nameji, Pikaareji (breadfruit), Dodo (Scaevola) and East Tagelib. There were small roosts at Mareri, Kirage, and Rakaaru (nine birds in a mangrove tree with an old nest). As indicated in my previous report, Noddies feed in large milling flocks on bait fish scared up by tuna. They scoop these fish from the surface as they hover or partially rest on the surface. They follow the movements of the tuna to new schools of bait fish, so they are always there when the spray begins to fly. Another entirely different type of foraging is indulged in individually - birds patrol the shores scooping small fish out of shallow pools. They thus cover vast areas in their feeding. This species is more abundant than stolidus, being overshadowed by the larger form only at the eastern tip of the atoll. Seven specimens were



taken; the food is Stolehorus delicatulus and small tide-pool fish. Parasites found were mallophaga, mites, louse flies, nematodes in the stomach, possible larval tapeworms? in the intestine, and flagellates in the caeca. Only individuals with large caeca have the flagellates.

Gygis alba, Fairy Tern, Mejo.- These were found in pairs or small groups around conspicuous broad-leaved trees where they roost at various times of the day and night. Their behavior is indeed mysterious, and never once did I see them feeding. Shortly after dawn I would see individuals and small groups coming in from the ocean. They were often seen carrying fish around as a display, but they seemed to spend all day calling, chasing and fluttering and roosting around inland breadfruit trees. One specimen was taken; it was carrying a dried 4-inch flying fish, Exocoetus volitans in its bill, and had in its stomach part of another flying fish and a hard shiny seed, which it may have picked off the water. The only parasites were mites. Though there was much chasing, calling and bearing of fish tokens, there was no evidence of nesting.

Ducula oceanica, Micronesian Pigeon, Mule.- For the distribution of the pigeon, see the accompanying map. / It was absent from many suitable areas, but it might visit them at other seasons or other years in following the breadfruit crops. However, the natives knew of no such movements, and recognized them as present on Arno, Ine and the eastern horn of the atoll, and nowhere else! Some, but not all, of the individuals were definitely breeding during the summer. A nesting pair was observed incubating from July 1 - 18, but failed in its efforts and deserted the site by July 21. One bird would pick off coconut leaflets from dead fronds high in the trees and would pass them to the brooding bird, which would then incor-

porate them into the nest under her, in the axil of a coconut frond. There was very little such nesting material aside from the coconut cloth that naturally would be found at the base of the frond, for none projected into view.

Pigeons travel long distances from one breadfruit grove to another, and fly from island to island. From July 10 until the end of August, about 10 birds were daily seen devouring breadfruits in a tall tree in King Tobo's yard. They completely stripped this tree, but passed over adjacent trees. In addition to breadfruit, they were noted eating Allophyllus fruit and papaya blossoms. Call-notes were to be heard as early as 5:45 a.m. and the birds are active in the breadfruit tree until about 6:30 p.m. Some are kept as pets by the people; they are recognized as being good to eat, but with the absence of guns, they are rarely if ever taken for that purpose. They apparently have forgotten the various primitive methods of capture. Two specimens were taken, and their only parasites were bird-lice.

Eudynamis taitensis, New Zealand Cuckoo, Udrej.- This solitary species spends its "winter" here and breeds in New Zealand. Single birds were seen 13 times in various parts of the atoll, always in dense forest. Only one was seen in the same area twice in succession, and it is likely that they roam over great distances. There is a rather set pattern of activity: a bird is usually first seen flying straight and swiftly through the trees; it alights on a dropping dead coconut frond, walks swiftly up it, sits very still for a long time, then leaps from frond to frond, spiralling upward into the crown of the tree, and finally flies off to another tree. Twice they were seen near the ground, where they would have to go in order to catch Ground Emoias. They display great agility in

leaping around in trees, as well as extreme stealth and secretiveness.

A single specimen which was preserved had eaten a four- or five-inch Brown Emoia, 5 green katydids, and a roach. Flagellates were present in its long caecum.

Delphinus roseiventris, Porpoise, Ke.- The same school of about 20 individuals played for hours on sunny mornings off the edge of the Ine anchorage reef on various days from June 23 to August 22. Another (or possibly the same) school was seen off the edge of the ocean reef at the western part of Ine Island. Slate colored individuals with pink bellies caught by natives at Pikaareji had apparently been driven into the lagoon. Dr. Hiatt has a complete description of the fantastic manner in which they are taken alive. They are much prized as food, and various sewing devices are made from the jaw bones. I saw no porpoises inside the Arno lagoon. I noted a different type with a light patch on the back, half-way between Arno and Majuro on August 9. I have furnished Dr. Remington Kellogg of the U. S. National Museum with the skull and all my notes in the hopes that he will be able to identify for us the various kinds. Two specimens were examined for parasites, and I found only tapeworms; one large kind with head embedded in the lining of the rectum, and a second smaller kind in the duodenum.

Pig, Bik.- Pigs are eaten <sup>on</sup> special occasions. Where they are not penned in, they tear up everything including the flagstones that mark the roads, and all the smaller vegetation. This destruction was seen at the southeastern portion of Ine. Usually they are kept in little log pens at the edge of the lagoon beach, and must be fed scraps and coconuts.

A great abundance of parasites were found in the nine stools examined: the protozoans Entamoeba, Trichomonas and Balantidium, and numerous nematode worms, not all identified yet, but including several pathogenic species as well as Trichuris. (These Trichuris ova had a somewhat different shape from those found so commonly in humans, and doubtless represent a different species.)

Cat, Kuj.- Strange to say, I found no feral cats out in the woods, though I did see them stalking rats out along the trail at the west edge of Ine Village. A female brought two rats within an hour to her nest under our house. They also eat breadfruit and coconut meat, and stand around waiting their turn when the chickens and other animals are being fed coconuts in the evening. They seem to be on friendly terms with the chickens and dogs and pigs. They are common pets, and appear to be of great use in Ine Village because they catch house rats. All are rather thin and scrawny, and the lighter colors predominate in their mixed stock.

Dog, Kiru.- Abundant around houses; none noted far from human companions. The dogs at Arno were of robust construction, and were all pretty much the same in form, and were mostly short-haired varieties. They find cool places to lie, preferring the soft sand dug up by crabs along the shady road; here they spend much of the day, each in its own favorite couch. There were very few females around Ine Village, and naturally each rare entrance of one caused a sensation! Also there were few pups in evidence - most of the dogs there were old battle-scarred veterans who lived in the hopes and expectations over their daily battles.



They are friendly but rather independent. One particular large one was a companion of the group of children who used to bring us specimens. He would bark and hunt with them, circling through the undergrowth when they were out hunting lizards and rats. He often scared away the herons that I was studying, and delighted in chasing birds along the beach. These dogs eat coconut meat along with the other domestic animals, and do not catch much of their own food. On Majuro, however, they roved in packs along the beach and were said to corner and catch fish cooperatively from tide-pools.

Rattus rattus, House Rat, Kijirik.- I found this rat only in and near Ine Village, but it is said to occur on a couple of islands between Dodo and Tagelib. These are the only places where green coconuts are cut into and eaten by rats; since the Polynesian Rat is found so abundantly all over the atoll in places where green nuts are not eaten, this is another line of evidence to acquit the dainty Rattus exulans of this offence. I trapped house rats on the ground, and also shot several from coconut trees at night; beneath these trees the ground was strewn with green coconuts in which a hole had been gnawed permitting the rats to enter and clean out the inside meat. Arnoese stated that this species had been rather recently introduced by the Japanese, and that before that time, no green nuts were eaten. My House Rat specimens are of diverse coloration, one being dark grey, indicative of admixture of native (?) island stock and Black Rat stock, the latter probably introduced from ships. These rats did considerable damage to stored copra and food in the Ine store and warehouse, and may be a contributing reason for the fact that the copra was always shipped out to Majuro as often as

possible. Two nests were found a few inches apart in a down rotten coconut log; one contained 6 young, the other, 3, identified as this species by their size. The nests and their location, however, were exactly like those of Rattus exulans, and the house rats either "copy" exulans in this respect, or have appropriated these nests from their rightful owners. Two unoccupied nests were found near the tree workings; they also resembled the nests of exulans. House Rats were sometimes seen out in the daytime; an indication that their numbers are great. None were found in my transect area about a half mile from the village. They are caught by cats in town, and some of the people set traps for them. It would be easy for the boys to kill them by placing husked coconuts (opened at one end) near their holes, waiting for them to enter the nut, then crack down on them with a club. Four specimens were preserved and sent to the National Museum. Stomachs contained coconut meat and green plant material. Two rats shot from trees in town had no ectoparasites, but others had mites and lice, but no fleas. There were abundant tapeworms and stomach nematodes and flagellates in the caecum. Rat tapeworms sometimes infest humans, but I found no evidence of tapes in the human stool survey.

The charge of eating green coconuts is a serious one indeed, and is already the cause of some concern to the people. (Coconut Crabs - see Dr. Hiatt's report - and Polynesian Rats eat only old fallen nuts, gleanings from the copra crop left on the ground because the people by no means take all the available nuts for copra. In fact they work the copra in a sporadic and rather disinterested fashion.) I think it would be easy to eradicate this rat from the few places where it has become established, by poison or trapping or by running them down with dogs whenever the piles of old coconut husks are burned. At least, those

whose trees are being damaged could easily contrive simple guards around the trunks.

Rattus exulans, Polynesian Rat, Kijirik.- This little rat is abundant and generally distributed even on some of the smallest islets. So many seen bouncing nimbly across the trail by day indicate tremendous numbers. They can also be seen climbing up and down trees, and poking around in the interior of the piles of coconut husks. The nest, a globular mass of soft dead leaves of whatever plants are handy (Pandanus, Polypodium, coconut cloth) about five inches in diameter is found inside of rotten logs, stumps, among the hanging dead leaves of Pandanus, and two were found each inside of a coconut husk. The rats are caught by cats. Near the nests, or on favorite eating places in Pandanus trees, eaten seeds of Triumfetta procumbens accumulate in piles. As determined by a microscopic comparison of stomach contents and coconut blossoms, they eat coconut blossoms, and are often seen at night climbing in the flowering stalks. Their main food is fallen coconuts. In spite of their abundance they have little if any influence on the copra production for only a small part of the available nuts are ever harvested.

My Ine friends, with whom I travelled to several islands, in an effort to be of help in my lofty researches and deliberations, would entice these tame little rats out from the piles of husks by strewing freshly opened nuts around. Within a minute or so the rats would come out, attracted by the smell, to be greeted with a rain of blows upon the head. My friends would then come to me, triumphantly bearing rats whose heads were reduced to pulp. No amount of explanation sufficed to get them to change their aim; apparently a block is involved, for when

they try to hit the rat elsewhere, they miss altogether. Thus I got measurements 17, and saved only 7 which had good skulls (trapped or shot at night). These specimens had mites and lice, flagellates in the caecum, whipworms threaded in the stomach lining, larger nematodes in the stomach, tapes in the intestine, and abundant ova of tapeworms and nematodes in their droppings. No biting true bugs (such as commonly carry blood diseases of rats) were found in the nests.

Homo sapiens, Man, Armij.- The predominant vertebrate on land, but far outnumbered by several species of lizards and by the Polynesian Rat. Signs of his activities are roads, trails, piles of defunct coconuts (the most important habitat of the smaller skinks, geckos and rats), artifacts such as baskets washed up on the beach, steps cut on coconut trunks, houses, etc. Man's main influence on the rest of the land animal and plant world is the clearing of undergrowth to facilitate coconut growth, and the burning of this trash. Thus the inhabited islands are very open (below the coconut and breadfruit canopy), an extreme of which is seen at Dodo, which is just like a park. Dodo also has the most modern type of dwellings and is the principal sea-port.

The thing that impressed me most about these people, aside from their friendliness, courtesy and generosity, was their intelligent interest in our projects. Unlike many native people in other areas where I have collected birds, they did not stand around and gawk at what we were doing. They actually understood what was going on, and furthermore, knew all the animals and plants, not merely by name, but in considerable detail as to natural history.



Concerning parasites, the following is the result of the Whidbey Survey at Arno and Ine Villages, May 2 and 3, 1950, respectively:

Arno: 126 stools, 110 negative, 9 hookworm, 6 Trichuris, 2 Giardia.

Ine: 127 stools, 98 negative, 2 hookworm, 12 Trichuris, 1 Enterobius, 9 Giardia, 2 Trichomonas, 7 Chilomastix.

My own survey of 100 stools from Ine Village was conducted with the assistance of Dr. Abija, who collected the samples. I examined a direct smear and a salt flotation of each. I preserved 40 slides of protozoa for further and more exact determination. The following results then are final for the helminth ova, but may be amended later for the protozoa. Only 36 stools were negative, thus indicating fairly extensive contamination of food by human excrement (indirectly of course).

Frequencies of various parasites and harmless inmates of the human intestine follow:

small flagellates	10
<u>Trichomonas</u>	14
<u>Giardia</u> (cysts only)	5
small amoebae	16
<u>Entamoeba</u> not yet identified	10
<u>Entamoeba histolytica</u>	12 (of which they were eating red blood cells in only three)
<u>Entamoeba coli</u>	13
<u>Enterobius</u>	1 (usually not found in stools, so this is not an indication of its actual prevalence)
hookworm	5
<u>Trichuris</u>	26

Only the three people with E. histolytica ingesting red blood cells would be liable to have symptoms or impairment of health (amoebic dysentery). Enterobius of course causes severe itching, but the hooks were not numerous enough to cause symptoms, Giardia and Trichuris are usually harmless, and the rest of the list is always harmless. All that these results show is that the mechanism for transmission of intestinal parasites is well entrenched at Ine, and that there is a reservoir of hookworm and amoebic dysentery which could spread if there would be a further lapse in the maintenance of sanitary conditions.

To summarize in another way, only 8 people out of the 100 had potentially pathogenic parasites, in the following combinations:

Lieonbad: Trichomonas, E. histolytica, hook, Trichuris.

Aikuj: E. histolytica with red blood cells, Trichuris, small flagellates.

Torta: hook, Trichuris.

Lini: E. histolytica with RBC, hook, Trichomonas, other flagellates, small amoebae.

Motodrik: Entamoeba coli, E. histolytica?, hookworm, Trichuris.

Kijeia: Enterobius.

Lawi: E. histolytica with RBC, Trichomonas.

Overton: E. histolytica?, hook, Trichuris.

#### General Remarks on Parasites

No protozoan or helminth parasites of the blood were found in any of the land vertebrates. There are fewer kinds of intestinal parasites here than in most tropical areas. The cause is doubtless the paucity of

animal life as compared with larger land areas, resulting in few or no intermediate or reservoir hosts, necessary in the life cycle of many parasites. The parasites that were found are almost all of the sort that need no intermediate host, and are passed directly from one infected person or animal to the next.

The reason that there are few human parasites on Ine, in addition to the above reasons, is that the people by custom defecate out on the reef where the tide carries away this excrement. There are certain well established customs and taboos dictating who goes to what part of the reef and with whom - certain relatives can go together, even if of different sexes, others cannot be seen in the act by certain relations, etc., etc., as probably expounded in Mr. Mason's report. However, our presence at the village upset this hygienic system. I was guilty of this as much or more than the others for I was always out along the edge of the island early in the morning looking at Reef Herons, etc. The people are very modest about being seen by us "civilized" folk, perhaps thinking that we would sneer at them for not using modern flush toilets! Consequently they would sneak out to the edge of the beach and defecate under cover of Scaevola and Pandanus trees, in places where the tide would not reach, and where the hookworm larvae possibly might be able to develop in the soil, and infect others who stepped there. Also the proximity of this material to places where food is being prepared would facilitate the contamination of food by cysts of E. histolytica through various agencies. Consequently my recommendation for preventing a general outbreak of intestinal parasites on Arno is that we stay away from the villages as much as possible, that we try not to interfere with and try

to encourage the maintenance of the venerable customs of these people. There are some difficulties here because the people are envious of certain of the trappings of our civilization. But I think it is easy to convince them to have a respect for their own customs, especially in this matter of sanitation, as I have tried to do, actually, at Ine. I do not mean to imply that we should turn back the clock and attempt to shield these people from our influences. That is impossible. "Civilization", for better or for worse, (mostly, in my opinion, the latter), has reached them and has been influencing them for a long time. But as an immediate practical measure on Arno (facilitated by its distance from a hotbed of western civilization at Majuro), is to encourage the people to continue their own sanitary customs. The few stinking privies that the Japanese built at Ine will soon fall from sheer weight of termites anyway; they are little used.

Lest it be thought that this is all idle speculation and worry over nothing, permit me to dwell upon the situation at Majuro, that is, the island upon which the naval base is situated. Hookworm and pinworm (Enterobius) are rampant there, to such an extent that the naval doctors were actually considering mass treatment for hook. The dependents of naval personnel are almost all infested with pinworm, and have constantly to be treated for that as well as for hookworm. I believe that in addition, some Ascaris has turned up there. There is a large native population there, unusually (for the Marshall Islands) crowded. There is not enough privacy for them to indulge in their traditional practices of defecation, nor, apparently, are there enough facilities and/or knowledge of their use, to accommodate them according to civilized standards. The result, judging from what the doctors said about the



incidence of hookworm and pinworm, is just about a complete breakdown of sanitation, and immanent probability (if not already) of building up enough hookworms in people to cause actual symptoms of the disease. This consideration touches close to home, for Ine Village is only a day's sail from Majuro. In fact, I judge that the Ine people who have hookworm probably picked it up at Majuro or some other island, because the situation at Ine (except during our stay there) is absolutely contrary to the interests of the hookworms.

### Termites

I found three species of termites at Arno. They occur in tremendous abundance, and play a most important and extensive role in breaking down all wood, dead branches and trees, stumps and logs, on the way towards its final reincorporation into the soil. It is practically impossible to find a piece of dead wood that is not riddled with termites. If you need wood for most any purpose you have to cut it green. It is of interest here that the earthworms also operate on the wood, though at a stage subsequent to the termite work. Taking coconut stumps as an example, the termites work in it while it is still sound and dry, a different kind of termite works in the damper portion and eventually the whole interior becomes damp and punky and rotten from the activities of a host of organisms. The worms work in this soft punky mass, where they are found in tremendous numbers. Of course the damp climate of Arno promotes the decay of wood by rot, fungi, etc., and the termites open it up to facilitate this process. Of the three species found, one is a very large form which is found in dry wood above ground, such as dead branches of Scaevola. A small, fast-moving kind is in damp wood

at the ground level, and may even work at the bottom of piles of coconut fronds. A small, slow-moving species, a miniature of the first, is found in the most sound wood, particularly erect coconut snags and buildings. Three species was more than Dr. Kirby expected to be found here. I made numerous slides of the flagellates in their hind gut. The community or "faunule" of various species of flagellates is different for each kind of termite, and thus comprises a useful indication of the course of evolution of their termite hosts. It is the action of these flagellates, either alone or perhaps in conjunction with associated bacteria, which makes possible the digestion of cellulose in the termite. Without them, the termite starves.

An additional note on the earthworms: these are much more active or muscular than those with which we are familiar at home. They can twist and squirm so violently when disturbed that they can actually jump several inches into the air. I watched a Golden Plover trying to kill one and the bird had great difficulty in keeping its grasp on the large worm, and could hardly subdue it. Ground Emoias eat the worms, for I saw a Black one with the end of a large worm projecting from its mouth. (Long worms must be swallowed gradually, as fast as digestion at the other end will permit.)

#### Time of Activity

Rain is very frequent here, and does not impede the foraging activities of most of the animals, except skinks. The small species of skinks definitely preferred the sun. Dasia was sometimes out in great numbers in the rain, at other times a sudden shower would send them all into hiding. I have considerable data on the time of appearance

in the morning of the various birds, of which I submit this record of August 4th as a representative example: (Ine Anchorage)

6:15 a.m. Pigeons barking in breadfruit tree (getting light)

6:20 and 6:45 Brown Emoias still dozing on their roosts

6:30 Pigeon in flight, Plover flies across the island

6:40 Tattler foraging on reef

6:50 Two Fairy Terns coming in from ocean, a small Noddy patrolling the shore.

7:00 - 7:10 Crested Terns, Herons, Golden Plovers and Black-naped Terns now feeding.

6:25 p.m. Brown Emoia and three Dasias roosting

6:30 Polynesian Rat ran across trail

before 7:00 Two House Geckos out

7:00 (getting dark, turn on flashlight and shine:)  
Big Geckos on all palms, Rock Geckos and House Geckos.

Noddy Terns fly around their roosting areas all night, shrieking and snarling; the shore birds call and fly on moonlit nights, and probably also feed (the Plover has a relatively large eye, permitting activity at night). Usually the shorebirds are the first animals to be heard in the mornings, their calls beginning at 6 a.m. when it is just barely light.

#### Seasonal Behavior

The shore birds and the Cuckoo are seasonal visitors here, and do not breed in this area. The Terns are undoubtedly permanent residents, but no evidence of breeding at this season was found. Old Noddy nests were seen, and some of the terns occasionally engaged in display flights. (In 1944 I found Noddys of both species nesting in large colonies at Eniwetok in October.) The only birds actually breeding during the

summer were Reef Herons and Pigeons, but only a few pairs were involved; the bulk of these populations probably breed at other seasons. Recently there has been intense interest in breeding cycles of oceanic birds, stimulated by Richardson and Fisher's work at Oahu, and well summarized in the most recent number of the American Scientist (1950, vol. 38: 613 - 616). Unfortunately, my data from the limited avifauna of Arno is negative evidence only; it would require a longer period of residence there to round out the story, which I might add, would be very worthwhile.

The lizards and rats breed probably continuously once they achieve adulthood. Ripe eggs and embryos (respectively) and young were seen all during the summer. All fully adult males had gonads of maximum size.

#### The "Hectare"

I laid out a study area on the narrowest part of Ine Island, a half mile west of Ine Village. It was a transect from ocean beach to lagoon beach, 43 yards wide (parallel to the beach) and 54 yards across the island (measured from the limit of vegetation on each side). Thus it included 2322 square yards of vegetation. I mapped out the plants, Konto identified them, and I entered on several duplicate sheets each vertebrate found so as to give an idea of their abundance and relative numbers, (see <sup>(Figs. 3 & 4)</sup> accompanying map). The vegetation consisted of a fairly continuous canopy of medium-sized coconut trees, Pandanus, and Scaevola thickets. In addition there were a few small or medium trees of Messerschmidia, Morinda, Guettarda but no breadfruit for a half mile in either direction. Part of the ocean side was clear and rocky, part of the lagoon side clear and covered with short grass, the rest was covered with thickets of vines: Triumfetta, Wedelia and Vigna. Other



small plants were the sedge, Fimbristalis, fern Polypodium (growing on stumps and logs), parasite Cassytha; Tacca, creeping grass Thurarea, milk weed Euphorbia chamissonis.

A trail cut through the middle of the area, on which people would walk or cycle from Ine to Jiyabo. A woman in the vicinity collected Scaevola flowers for garlands, and a man came through one day taking hermit crabs for bait. He had a club and a gallon tin; he would poke aside the skirt of hanging dead leaves on each Pandanus and rake out the crabs with his stick and put them in the can. Like the people, a Pigeon and a Cuckoo came across the "hectare" on the way to Jiyabo from Ine Village. Terns, shorebirds and herons worked the edge of both beaches. The following are the numbers of land vertebrates found:

Rock Gecko	4
House Gecko	8
Big Tree Gecko	25
Four-fingered Gecko	1
<u>Dasia</u>	8
<u>Emoia cyanura</u>	18
Brown <u>Emoia</u>	4
<u>Rattus exulans</u>	7
Total:	75 vertebrates in residence on the plot.

These figures represent minimum numbers, such as found in a rather unfavorable environment. There was only one pile of old coconuts, and no breadfruit trees; these form principal concentration points for skinks and rats, and occur more numerous elsewhere. A transect at the anchorage point near Ine Village would yield double the numbers for each species.

### General Remarks on Carrying Capacity

The lizards and Polynesian rats occur in such abundance that it can safely be said that they have saturated their available environment. Though the fish supply could support many more terns and herons, they are probably limited by available nesting places during whatever seasons they nest. The Micronesian Pigeon is absent from several areas that look like perfectly good pigeon habitat. My guess is that rats hold down their numbers by raiding the nests. Nesting time is a very critical one for pigeons; they have very flimsy nests which are likely to be blown down by wind, and the fact that these particular pigeons nest in coconut palms, in which rats spend so much time, leads me to believe that the rats could very well prey on the eggs and nestlings. At least it can be said that the pigeons are not parasitized and are not hunted nor persecuted by man. I have no direct evidence to support my speculation on rats vs. pigeons, but the one nest that I was able to find all summer certainly did wind up in disaster from some cause.

The reasons why Arno has so few kinds of resident land birds (only two - the heron and pigeon) is that it presents little variety in habitats for land birds. This is more important, I think, than the fact that Arno is far removed from areas with large avifaunas from which it might be colonized by additional birds. If we compare it with Ulithi Atoll, situated near the Marianas and Yap, we find a comparable paucity: Ulithi, providing similar monotony of habitat as Arno, has only the Reef Heron, Micronesian Starling (?), and for mammals, apparently only the Fruit Bat and House Rat.

Concerning the oceanic birds, possibly more kinds will be found breeding here than the five species of terns. But many kinds of oceanic

birds are prohibited from nesting here by the absence of high ground. Several of the kinds need cliffs for nesting, and high rocks jutting from the sea, from which they can take off. (Many are unable to get underway in the air without a preliminary glide off some high point.)

The House Rat is still circumscribed in its distribution and abundance. It is hoped that it can be prevented from further spread, which would be a hazard to the copra crop. Man and his domestic animals are the land vertebrates for which Arno is most understaffed. I doubt if even half the land area of Arno is settled, and of the settled portions, only a portion of the available coconut crop is utilized. Most of the nuts sprout or rot upon the ground. Breadfruit is used to capacity, and there is some disease of the fruit that is reducing its availability. But there are many parts of the islands wide enough for breadfruit to grow, in which few if any trees exist. As stated in my previous field report, the rich supply of marine food is almost untapped. There is more than enough water, fish, coconuts and land for the present population; also, as pointed out under my account of pigs and chickens, there are many more of these domestic animals than needed. The introduction of rabbits, ducks, turkeys, goats, etc., would give them more variety, but with the present population would not fill a crying need for more basic food sources.

Concerning food cycles of the land animals, the "law of the jungle" is not much in evidence. Beginning with vegetation eaten by insects, the insects are in turn eaten by the various lizards, and here we come to a dead end, as far as the bulk of the lizard population is concerned, for relatively few of them are eaten by cuckoos, chickens and herons,

all of which have as their principal food, some other source than lizards. Again beginning with vegetable food, it is eaten by rats. Here again is a dead end, for the rats are eaten by cats only near human habitations.

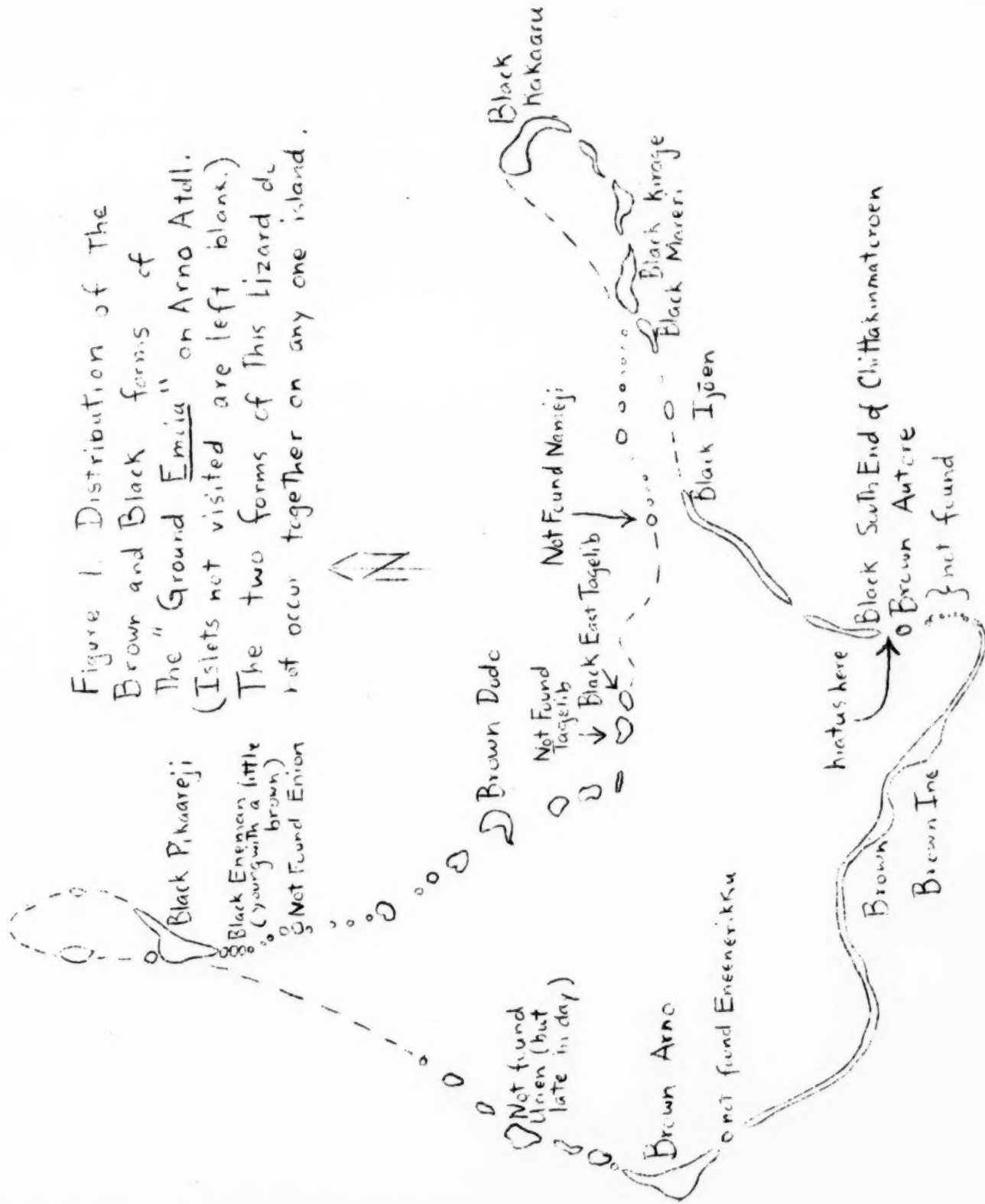
Because of the paucity of land animals, we do not find an over-all food chain, or chain of interdependence.



There is a great deal of  
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Figure 1. Distribution of the Brown and Black forms of the "Ground Emia" on Arno Atoll. (Islets not visited are left blank.) The two forms of this lizard do not occur together on any one island.









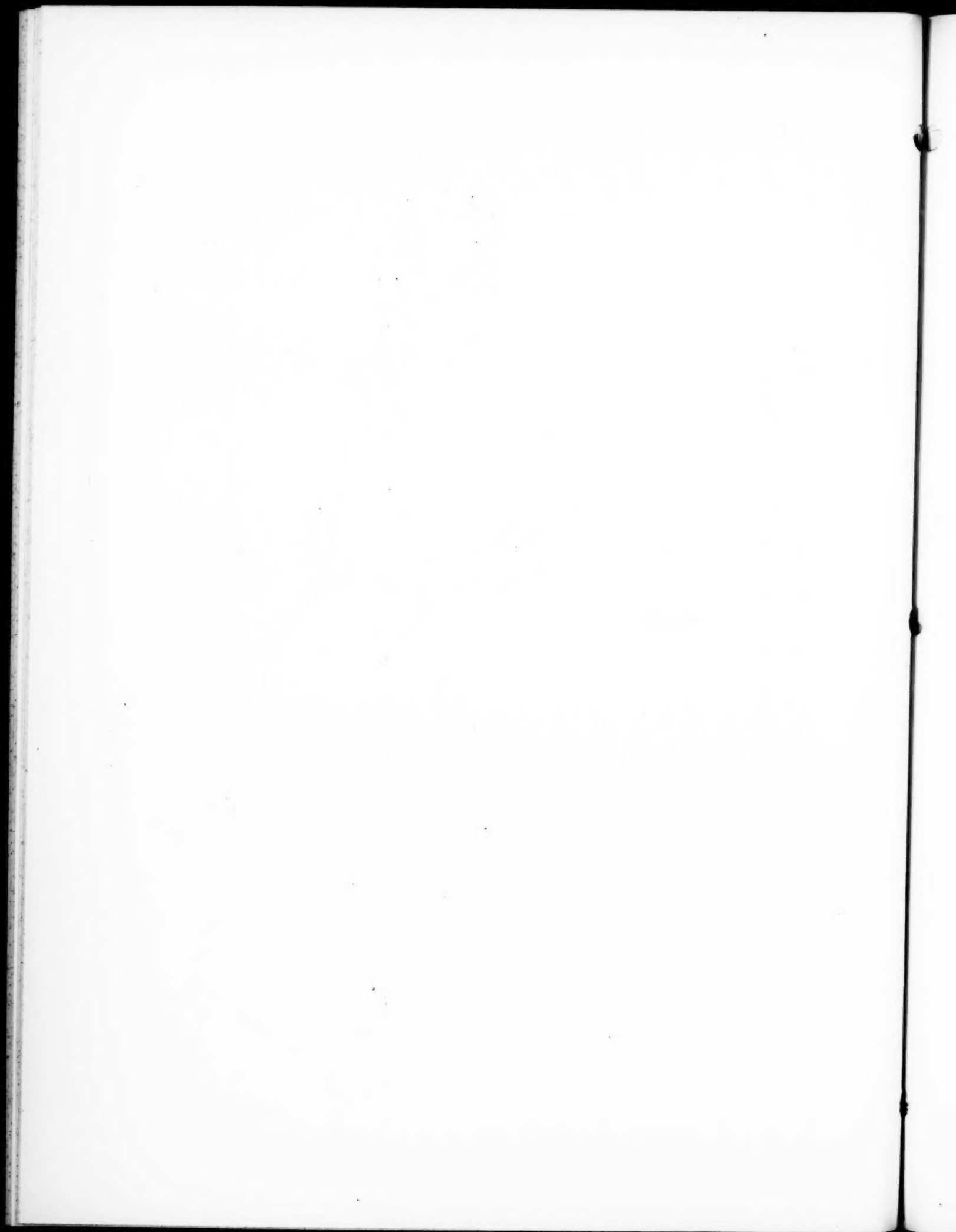


Figure 3 Plants and Gecko Lizards of The "Hectare."

- |   |   |   |                         |
|---|---|---|-------------------------|
| R | "Rock Gecko", <u>Gymnodactylus</u>            | ● | Coconut Palm            |
| T | "Big Tree Gecko", <u>Gehyra</u>               | ○ | " stump                 |
| 4 | "4-fingered Gecko", <u>Hemiphyllidactylus</u> | — | " log                   |
| H | "Small House Gecko", <u>Lepidodactylus</u>    | ⊗ | " husks                 |
|   |   | * | <u>Pandanus</u>         |
|   |   | ☆ | Dead "                  |
|   |   | ☁ | <u>Scaevola</u> Thicket |

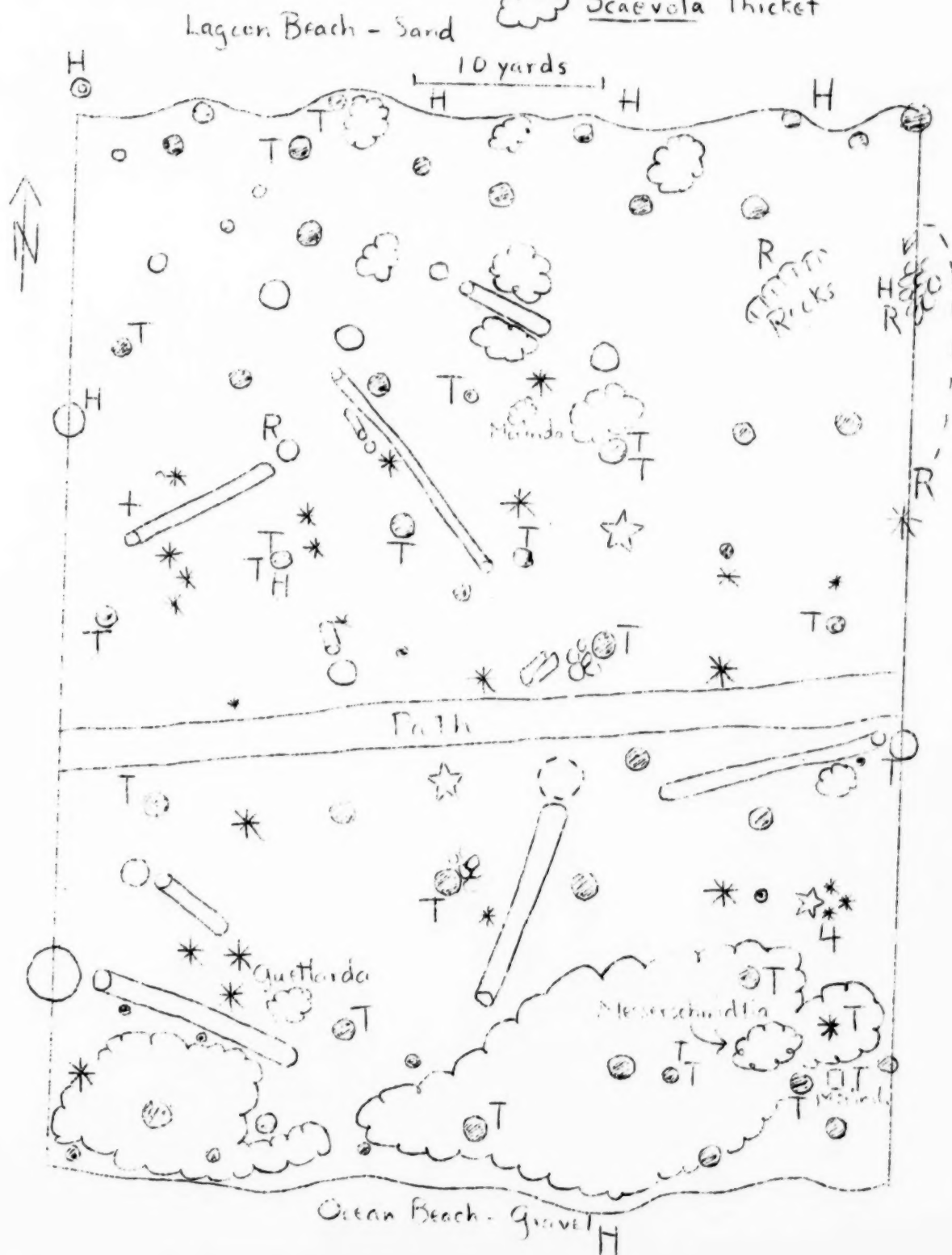




Figure 4. Skinks, Rats and Rat Nests of "Hertare"  
Emicla cyanura not shown — 12 were present  
 on ground and in vines

D Dasia sinuagadina  
 G "Ground Emicla"

R Rattus exulans  
 Nest Nest of R. exulans

10 yards

